Ohio Agricultural Experiment Station.

BULLETIN 89

WOOSTER, OHIO, DECEMBER, 1897.

PREVALENT DISEASES

OF

CUBUMBERS, MELONS AND TOMATOES.

The Bulletins of this Station are sent free to all residents of the State who request them. Persons who may receive duplicate copies, or who do not care to receive any, are requested to notify the Station. All correspondence should be addressed to

EXPERIMENT STATION, WOOSTER, OHIO.

NORWALK, OHIO:
THE LANING PRINTING CO.
1897.

ORGANIZATION OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

BOARD OF CONTROL.

SETH H. ELLIS	Springboro
R. H. WARDER	North Bend
J. T. ROBINSON	Rockaway
THE GOVERNOR OF THE STATE THE DIRECTOR OF THE STATION	*Ex officio*

OFFICERS OF THE BOARD.

SETH H. ELLIS	President
R. H. WARDER	Secretary
PERCY A. HINMAN	Treasurer

STATION STAFF.

CHARLES E. THORNE	Wooster	Director
WILLIAM J. GREEN	"	Horticulturist and Vice-Director
J. FREMONT HICKMAN, M. A. S	"	Agriculturist
FRANCIS M. WEBSTER, M. S	"	Entomologist
AUGUSTINE D. SELBY, B. Sc	"	Botanist and Chemist
LLOYD M. BLOOMFIELD, B. AGR	"	Assistant Chemist
CHARLES W. MALLY, M. Sc	"	Assistant Entomologist
PERCY A. HINMAN	"	Bursar
WILLIAM HOLMES	"	Foreman of Farm
CHARLES A. PATTON	"	Ass't Foreman and Meteorologist
DELBERT A. CROWNER, B. Sc. AGR	"	Dairyman
ANNIE B. AYRES	"	Mailing Clerk
S. J. BLAKE	"	Mechanic
W. E. BONTRAGER	"	Foreman of Greenhouses
EDWARD MOHN	Strongsville	Supt. Northeastern Sub-Station

The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Anuual Report, which constitutes the final number of each yearly volume.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 89. DECEMBER, 1897.

PREVALENT DISEASES OF CUCUMBERS, MELONS AND TOMATOES.

BY A. D. SELBY.

CUCUMBER DISEASES.

THE PICKLE INDUSTRY.

Beginning in 1891, there has developed in this county, Wayne, a new and considerable industry among the farmers and gardeners, namely, that of cucumber pickle growing. The acreage has yearly increased and new companies have been attracted to the region. Three salting works are in operation ; one each at Creston, Smithville and Wooster, and a factory or preserving works, likewise at Wooster. During the past three years the area of cucumbers at Creston has been from 175 to 225 acres each year; at Smithville, in 1897, 400 acres, and at the Wooster salting works 300 acres. In addition to this 150 acres more are to be required by the preserving works of Wooster in 1898, besides increase of acreage at other works. The pickles include the small cucumbers only; the limit of maximum size varies from $3\frac{1}{2}$ to 4 inches in length—minimum $1\frac{1}{2}$ inches. The price paid for these pickles has been from 40 to 45 cents per bushel in 1897, and from 50 to 55 cents per bushel in earlier years. In addition to the small, true pickles, some of the larger sizes are accepted by the contractors at from 10 to 15 cents per bushel. The large pickles make up about one-fourth of the total crop. Growers of pickles take little or no account of the larger cucumbers, such as are sold on the market for immediate table use, and cucumbers are "pickles" in the parlance of all these growers.

The crop is almost entirely grown under contract each season, the respective growers each agreeing to plant and tend and to deliver the product of a specified number of acres of cucumbers, ranging usually from three to ten acres, and sometimes amounting to twenty-five acres under a single contract. The pickles are cut every second day and delivered to the factory in bushel boxes. The crop is planted rather late, about June 10 to 15, and the pickles are commonly gathered from August

1st, until frost kills the vines in late September. Frost usually destroys the cucumbers from September 20th to 25th. What has just been stated applies to this immediate district; the practice differs in many points from the growing of cucumbers for city markets, in which earliness may be the chief condition of profit. Besides these market districts there are other areas, in Ohio, devoted to pickle growing. Such a one is found near Cincinnati.

Outside Ohio, pickle growing is a conspicuous industry in southeastern New York, especially in Westchester county and on Long Island.[1] Allegheny county, Pennsylvania, is the seat of a similar industry, while Jackson, Monroe, Oakland, Ottawa and Saginaw counties, in Michigan, are conspicuous for pickle farming; this is more especially true in the counties of Jackson and Oakland. In Indiana, La Porte, Marshall and St. Joseph counties contain several salting houses; pickles are grown in Kenton and Campbell counties, Kentucky. Illinois, Iowa and many other states present analagous conditions.

It may be seen from the brief statement above given, that pickle growing is an intensive form of culture. Persons actually growing pickles do not need to be reminded of the labor involved. Preparation of seed bed, planting the seed, fighting or surfeiting the cucumber beetles, cultivating the soil and finally, the hand gathering, combine to demand great care and labor; the return per acre must be correspondingly large to repay the cost of growing.

THE YIELD GROWING LESS.

From data at hand it appears that the Creston growers harvested, in 1895, 57,000 bushels of pickles from 200 acres; in 1896, 37,000 bushels from 175 acres; and in 1897, 16,000 bushels from 225 acres under contract. These returns indicate, in 1895, a yield of 285 bushels per acre: in 1896, 210 bushels per acre; and in 1897, only 71 bushels per acre! At Smithville, in 1897, 33,000 bushels were obtained from about 400 acres, or 82½ bushels per acre! The figures for Wooster are less discouraging, yet fall short of reassurance. From a Cincinnati pickling house we learn that their growers, chiefly in Kentucky along the Licking river, suffered severely. Some growers did not get to pick the crop more than two or three times before their vines were all dead. "Our farmers in this section did not average more than twenty bushels to the acre when the usual crop is from 100 to 300 bushels to the acre." "Perhaps 66 per cent., an average crop," is reported by a prominent pickle house as their return on Long Island, New York, and at Wooster, O. [This estimate seems about double that of others for these districts.] "The crop was not up to the standard in Indiana, Michigan or Iowa." Information from New York, previous to 1897, is given by Stewart[2] who reports

[1] Stewart, F. C. Bull. 119 (N. S.) N. Y. Experiment Station.

[2] Loc. cit. p. 155.

the yield for 1896 as about one-fourth a crop; that is, an average yield of 19,288 pickles per acre was obtained from 817 acres. A fair average crop there is reckoned at 75,000 pickles per acre, with 125,000 per acre as having been in the past not an "unusual yield." "But during the past five or six years the yield has decreased rapidly; reaching so low a point in 1895 and 1896 that the crop ceased to be profitable." "In spite of the poor crop of 1895, farmers continued to plant heavily in 1896, being loth to give up a crop so admirably adapted to their soil and climate." "Moreover they believed that the season of 1895 was exceptional and that with the return of normal weather conditions the cucumber disease would disappear and the crop continue to be as profitable as it had been in the past." "But when the disease reappeared in 1896, more virulent than ever, they became discouraged and many of them decided that they must quit gro w ing cucumbers." It will be perceived that the diminishing return from pickle acreage is a matter of moment to the growers of this crop. It may also be inferred that this condition is likely to continue, unless preventives may be at hand for the cause of the diminishing yield. To these remedies we will return later.

THE CAUSE OF DIMINISHING PICKLE YIELDS.

Several conditions may have influence in reducing the yield of such a crop. Among these we may name a bad stand of vines, resulting from any cause, and unthrifty growth, followed, usually, by premature death of the plant. Careful study of all the possible agents or causes in the field is the only means of pointing out the influential ones. While this has not been done fully in the present instance, fair approximation has been made. The chief factor has received careful study.

Pickle growers had, perhaps, more than average difficulty to secure a good stand in 1897. The cold, rainy weather earlier, and the soil conditions following, rendered much replanting necessary. In addition, the late July and early August temperatures were quite low; however, this condition was unfavorable to fungus development and must be estimated on both sides of the question, since, if unfavorable to the growth of fungi their destructive influences, when present, would not be apparent so early. The cucumber beetle and the melon louse were not apparently more injurious than in other years. The damage from bacterial blight[3] or wilt disease was not reported or observed to be more prevalent than for a few years past. From it, as from the insects named, the maximum injury results in the earlier stages of the growth of the cucumber plant.

The course of the chief trouble, in practically all the pickle districts complaining of greatly shortened crops, has been described in almost the same terms. Writes one pickle firm: "The prospects for a crop were very flattering, had good growth of vines, good color, but from the first to about the middle of August the vines took some kind of disease and

[3] Bulletin 73, p. 233.

turned yellow; the patches died out very rapidly, some farmers did not get to pick their crop more than two or three times before all their vines were dead." Another statement comes to us in similar language: "The vines never looked better just after starting to pick cucumbers. Twenty-four hours after making the observation the vines were destroyed by the mildew or blight." The first of these shows just the state of things met with in Wayne county districts visited by the writer in August.

On August 21, a Creston pickle grower brought me specimens of dying cucumber vines, stating that an adjacent field was at that date nearly or entirely destroyed. That the vines had begun to turn yellow in spots, and that soon after the whole had succumbed. A very few pickles were upon the ends of the vines but these were "nubby," and worthless. Upon the plants brought, no evidences of serious stem or root injury were visible. Where the striped beetles had abraded the stems, healing appeared to have, in a measure, repaired the injury. The leaves were conspicuously affected. Older leaves were yellow, with occasional circular or angular dead spots in them; the angular, yellow spotting, usually characteristic in the less discolored leaves, was not conspicuous on these specimens. Microscopic examination of the diseased spots showed a fungus present in nearly or quite all of them. This fungus was at once identified as the probable cause of complaint. It proved to be downy mildew, *Plasmopara Cubensis* (B. & C.) Humph; a disease found in my own garden at Wooster in 1895[4]. Three days later cucumber vines similarly diseased were brought from Weilersville. To both these growers spraying with Bordeaux mixture was recommended as a possible check to the disease, although it was then too late to secure anything but partial results. Warning of the trouble was also given.

August 28, more extended examination of pickle fields in the county was begun and followed by later visits. Upon the date named many large fields were past return. In some instances but two pickings had been secured. Upon one farm, where three fields of cucumbers were growing, two of them had been abandoned and the third yielded but a single cutting afterward. Of these fields the one least affected at that date had been in the same crop for two successive seasons, while one of the abandoned fields was upon fresh land and the other was the third crop of pickles. Occasional fields were seen that showed no evidences of disease, while others not far away had been forsaken. The overwhelming evidence pointed to the downy mildew as the essential cause of the pickle failure; it was found upon the vines in every field of prematurely dead vines. Certain fields, then of good appearance, were subsequently stricken, dying very rapidly with all the characteristic spotting and yellowing of the leaves.

[4] Bulletin 73, p. 234.

APPEARANCE OF CUCUMBER VINES ATTACKED BY DOWNY MILDEW.

The symptoms of this trouble are quite well marked, so that a person who has once seen plants affected with downy mildew may be quite certain upon meeting with it again. The reports that have been quoted describe briefly the general appearance of a field attacked by downy mildew. There is a decided yellowing of the leaves, this is followed by their drying up from the center of the hills outward. That is, the leaves perish in the order of age, the oldest first, a few green leaves remaining for some time at the tips of the vines. The spotting of the leaves is the most characteristic feature. It is, generally, the gross character which may not easily be mistaken. Older leaves affected with downy mildew may often lack this distinguishing, angular, yellow spotting described later, and show only occasional, circular, dead spots in the yellowed leaves. These remain visible in the dried specimens. But the clear character of the disease, in fresh leaves in the field, is the presence of angular, yellowish spots, usually four-sided in outline, one-eighth to one-fourth inches across, bounded by the veins and veinlets of the leaf. This contrast is represented by dark and light in Plate I. The actual contrasts are best shown in the living colors. A fresh leaf of this sort, held between the observer and the light will give a good view. Leaves exhibiting these features indicate a stage in the development of the fungus; they are most abundant between green tips and the older, uniformly yellow leaves. Often, as may be seen from the figure, two or more spots coalesce and give a larger area of yellow; the final yellowing of the entire leaf is ascribed to the merging of the affected spots. After the spots unite, all becomes practically of one color, when the leaf shrivels and dies as if by frost. In hot weather the spots quickly involve the whole leaf before there has been much or any drying of the spotted areas, while during cool, unfavorable weather the yellow spots remain longer distinct, and some of them become dead and brown in the centre. It is this matter of favorable or unfavorable weather for the fungus to develop, which explains the varied appearance of leaves at different times, as for example, the numerous dead spots in the specimens of August 21. The older spots often show a downy appearance beneath. Whatever be the weather as to temperature and moisture, it is but a short time after the appearance of the yellow spots in the leaves until picking fails to give a good return. Clusters of green leaves remain at the tips of the stems, but the amount of fruit set is small and much of that is stunted, misshapen and "nubby." Such stock is not fit for the uses intended.

NATURE OF DOWNY MILDEW FUNGUS AND ITS MANNER OF SPREAD.

This diseased condition, which has been described, is due to the downy mildew fungus, *Plasmopara Cubensis*, as previously stated. The downy mildew is a minute plant parasite, which lives at the expense of the cucumber plant; it has the power to rob such other plants besides

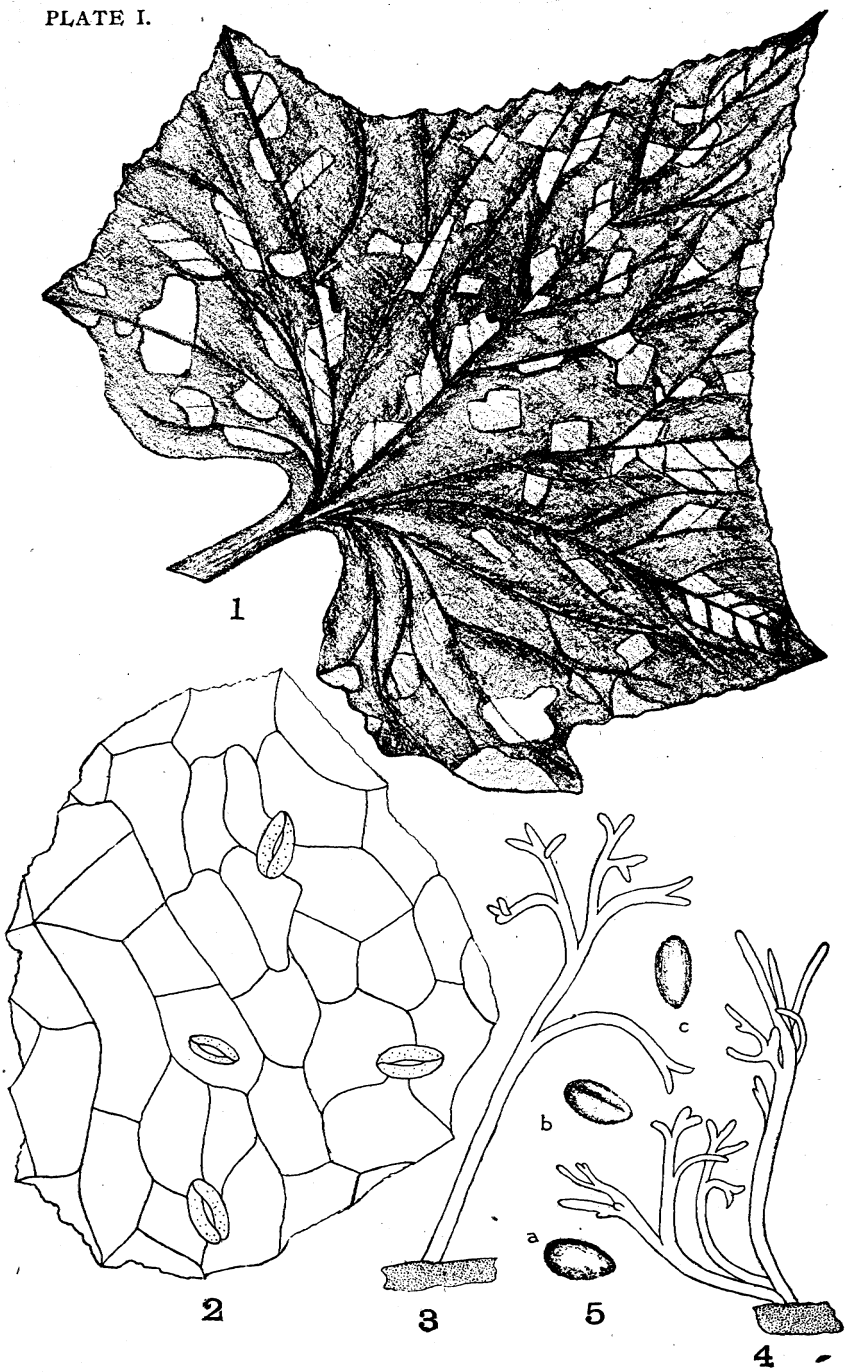
the cucumber, including the muskmelon, pumpkin, squash and watermelon, as furnish it a suitable substratum. This downy mildew belongs to the same order as the downy mildew or *Peronospora* of the grape, namely the *Peronosporeæ*: the potato rot or *Phytophthora* belongs to the same group of parasitic fungi. Lettuce[5] suffers from downy mildew, as do spinach, peppergrass and tall fivefinger. The white mold *Cystopus*, upon shepherd's purse and the similar one upon purslane, noted in Bulletin 83 as so destructive to the weed, likewise belong to the order named. But while the downy mildews just named attack the various hosts specified, and possibly some related plants, that of cucumbers, muskmelons, pumpkins, and watermelons is the same for all and may be expected to spread from one to the other, when they growing in adjacent fields.

This downy mildew, like its cucumber host, springs from a seed body or spore, as it is called. Just the form and nature of the winter-surviving spores, is not known for this one; we know that in the grape and some others it is a large, well protected spore (óöspore) found in the part affected, as in leaves or stems. It is evident we are to expect the fungus to survive and to reappear in or near fields in which it has been prevalent. This has been the case in New Jersey and New York, where reports have been made of its occurrence. It is what took place in my garden, the disease appearing with greater injury the third season. By examining a section through one of the diseased spots of a cucumber leaf, under the microscope, we obtain an idea of the appearance of this parasite. At proper stages of growth we may see the threads of the fungus growing among the cells of the leaf; how the fungus gains entrance will appear later. A section of diseased spot when magnified about 500 diameters will show, projecting from the under side of the leaf, growths or threads like that in Figures 3 and 4, Plate I. Upon these branches may be seen the somewhat violet-colored spores, or *conidia*, of the mildew. This violet color is often conspicuous on specimens from the greenhouse and also upon muskmelons. The spores will be entirely or largely detached unless great care is used, both in selecting material and in making the sections just described. These spores are the seeds for the further spread and growth of the downy mildew. They germinate after but a few hours, under suitable warmth and moisture, and being in such numbers are capable of scattering the disease very rapidly. In germination each spore throws out several small bodies called zoöspores or swarm spores; each zoöspore may send out a germ tube which may enter the leaf by one of its openings, called stomates.

Having these tangible spores, even though they are minute, we may undertake to learn how they attack the cucumber leaf. The leaf of the plant is a working organ having in it many openings, communicating between the interior of the leaf and the outside. These pierce the skin

[5] Bulletin 73, p. 226.

PLATE I.



Cucumber Downy Mildew. Fig. 1, diseased cucumber leaf, natural size. The light areas represent the yellow spotting. Fig. 2, epidermis from upper leaf surface of cucumber, showing stomates. Figs. 3 and 4, spore bearing branches of thefungus. *Plasmopara Cubensis*, from dried specimen. Fig. 5, a, b, c, spores (conidia) of the fungus; b shows grooved or collapsed condition. Figs. 2, 3, 4 and 5 magnified about 500 diameters. (From drawing by Mrs. Selby.)

or epidermis and thus provide a way for the germ tubes to enter into the living parts. The pores or stomates may be likened to the clefts of rock into which roots of trees may penetrate, or to our own respiratory passages through which, despite their many turnings and possible lodging places, the germs of diphtheria or consumption are conveyed by air currents to find at last their needed place of growth.

The openings or stomates of the cucumber leaf are more numerous in the under surface than in the upper, there being about two and one half times as many upon the lower surface. The actual number upon a leaf reaches into the hundreds of thousands. In addition to stomates there are roughening hairs upon both leaf surfaces; these hold drops of water in which the spores may lodge and germinate. A germ tube once within the leaf, feeds abundantly upon the leaf juices, branching and growing between the cells. These threads (*hyphae*) are colorless, as are those represented in the figure; they send at times sucking branches (*haustoria*) into the leaf cells. Besides the robbery of food material there may occur poisoning of the cells of the leaf. After a short time the ungus is ready to form spores; this it does by sending out spore-bearing branches through the stomates in the under leaf surface. Such branches are represented in the figure; the spore-bearing branches give the downy appearance sometimes observed. Thus while the growing spores may enter through the stomates of either leaf surface, the fungus branches bearing them anew are sent out only from those of the lower surface. As we shall presently see, it is from the upper side and through the fewer stomates, that the germ tubes are most likely to obtain entrance. The spores are very small, about 1000 of them being necessary, when placed end to end, to cover the length of one inch; more will be required when placed side by side. Being so light, they are readily carried by the wind, and will be deposited chiefly as dust, upon the upper surface of the leaves. With dews or gentle showers, moisture for the growth of the swarm-spores will be provided; rapid spread of the disease may accordingly be expected when warm weather and abundant moisture, especially at night, occur together. The temperature is an important condition. Doubtless had the weather turned hot late in July of the past season and continued thus, the collapse of the pickle-vines would have occurred early in August, perhaps during the first week of the month, instead of during the third and fourth weeks or even later. With average July weather the destructive effects, if left unchecked, may be expected very soon after the first of August; in exceptional seasons this may happen even earlier than the date named.

Dashing rain may favor the spread of the mildew; if the spores have been scattered in great abundance upon the earth the spattering drops might carry them to the under leaf surface. But it would require unusual conditions to make the under surface infection by mildew spores approach, in amount, that by the upper surface. *In this we may understand how destruction of the spores*

upon the upper leaf surface, or prevention of their growth, may largely prevent injury from the downy mildew. As shown, this may be accomplished by keeping the upper surfaces of the leaves covered with a fungicide, such as Bordeaux mixture.

HISTORY AND DISTRIBUTION OF THIS DISEASE.

The history of this trouble is not an extended one, yet its restatement may help in later considerations. The fungus was first described in 1868, by Berkely and Curtis,[6] from specimens on a wild plant from Cuba. It was, at the time called *Peronospora Cubensis.* In 1888 the same fungus was found upon cucumbers in Japan[7]. Meanwhile, before this fact had been published, that is in 1889, Dr. Halsted, of New Jersey, had found the fungus upon hot-bed cucumbers at New Brunswick.[8] He then expressed the fear that "Market gardeners may have in the cucumber mildew a serious enemy, especially should it spread to squashes, melons, and other members of the *Cucurbitaceæ*, and attack the seedling plants." It was afterwards found by him upon cucumbers, squashes and pumpkins in various parts of the State.[9] The same year it was reported by Professor Galloway[10] from Anona, Fla., and College Station, Texas. Humphrey[11] reported it from Massachusetts, for 1890, upon garden cucumbers and squashes. He changed the name to *Plasmopara Cubensis* (B. & C.) Humph., since it was found to belong to that genus. In 1891 it was again reported by Dr. Halsted[12] who found it almost everywhere about New Brunswick, though it had not been observed in 1890. Watermelons were attacked by it both there and at New Haven, Conn. The same disease was again prevalent in New Jersey in 1892 and in 1893. About this time it began to be destructive to field cucumbers in southeastern New York,[13] where it continues to be prevalent and destructive to the present time. In 1895, the same trouble appeared in forcing houses in Ohio and in the writer's garden at Wooster,[14] but did not prove serious.

In 1896, it was very destructive in forcing houses at Hyde Park, and while not reported or studied, so far as known, in the pickle fields of Ohio and Kentucky, where the disease proved so injurious in 1897, there are some evidences, chiefly later inferences from observations made at the time by growers, that the downy mildew prevailed to a more limited

[6] Journal Linnæan Society, Botany, x, 363.

[7] Farlow, W. G. Botanical Gazette xiv, 189.

[8] Botanical Gazette, xiv, 152-3.

[9] Journal Mycology, v. 201.

[10] Journal Mycology, v. 216.

[11] Eighth Annual Report Mass. State Ag'l Exp't Station, 210-12.

[12] Report Botanist N. J. Exp't Station, 1891, p. 248. See also Report Conn. Exp't Station, 1891, p. 97.

[13] Stewart loc. cit., p. 155.

[14] Bulletin 73, pp. 231-4.

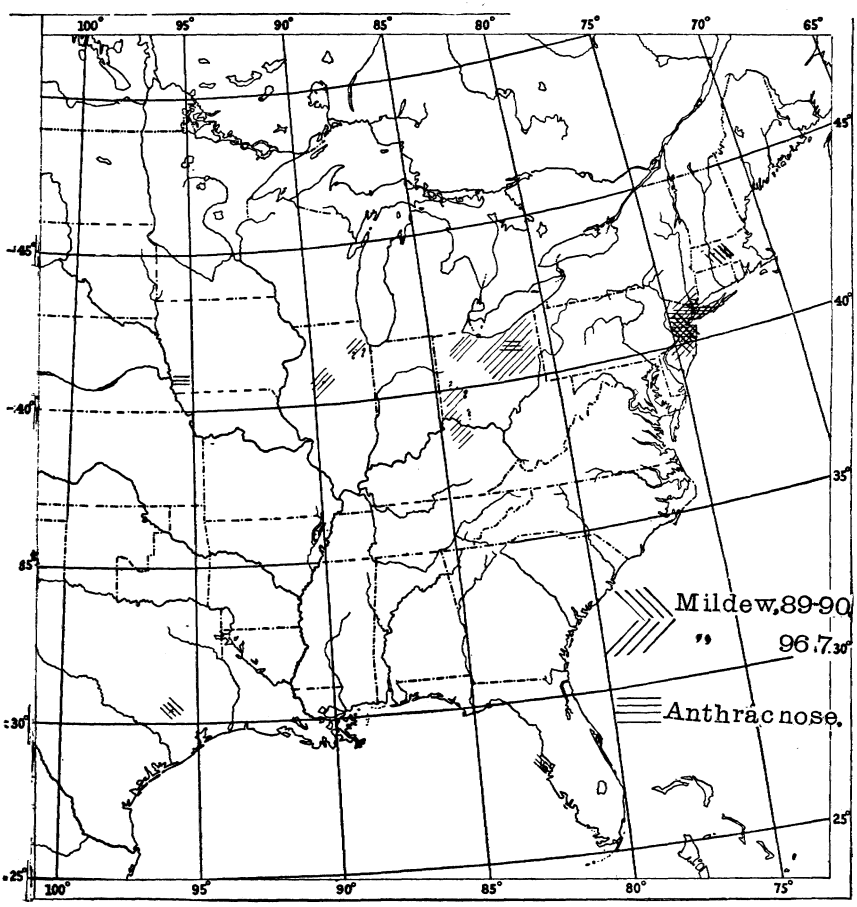
extent in 1896. For the season of 1897, downy mildew prevailed to a highly injurious degree in Ohio. It was collected by the writer in Wayne and Summit counties and found upon specimens from Wood county, while from descriptions furnished by growers and others there is little doubt of its wide distribution in the State. Mr. A. Shirer reports early death of cucumber vines about Dayton. The distribution is indicated on the map.

Some effort has been made to learn of the wide distribution and current injury of downy mildew in the United States. Thanks to the responses of those addressed, we are able to gather some information worthy of record. From Prof. Stewart we learn that in the vicinity of New York City the pickle crop of 1897 has been somewhat lighter than in 1896, and that this has been due to four principal causes: (1) Unfavorable weather, (2) Downy mildew, (3) Anthracnose, (4) the bacterial wilt disease. He is unable to decide which has done the most damage. "The downy mildew has been less virulent than in 1896." "It was about two weeks late in making its appearance and this I attribute to the fact that the latter part of July and the first two weeks of August were unusually cool, whereas, the first two weeks of August, 1896, were excessively hot." "Downy mildew prevails in New Jersey," writes Dr. Halsted. No information of its occurrence in Pennsylvania is at hand. For Ohio the condition has already been stated, while Kentucky growers report to the Ohio firm with which contracts are made, very great losses from a trouble whose description agrees with that of downy mildew. These reports are from Kenton and Campbell counties. The disease has not been observed in Indiana by Professors Troop and Arthur. While the Michigan crop has been somewhat shortened by seasonal or other conditions, Professor Taft has not met with the downy mildew in that state. Dr. Burrill reports that serious troubles were encountered both last year and this, in the pickle growing region about Chicago. That while one or more diseases are seriously suspected, no investigation has been made. Professor Pammel has not found downy mildew or anthracnose in Iowa nor have Professors Whitten and Trelease in Missouri. The recorded occurrences of downy mildew and anthracnose of cucumbers in the United States are shown on the accompanying map. Some doubtful or undetermined areas are indicated by question marks.

WILL THE DOWNY MILDEW OCCUR IN 1898?

It is plain that the chief good to be obtained from the inquiry made as to the distribution of downy mildew is to come in the future. "Are we to expect recurrent or continuous outbreaks of the disease?" is easier asked than answered. The probable reappearance of the trouble may be inferred from the nature of the malady. The fungus is reproduced by spores and a crop of these will be produced in diseased fields. We note that downy mildew in 1897 followed the disease of 1896, in New York;

that it was prevalent in New Jersey in 1891 and in 1892 as well as since. It was very destructive in a greenhouse at Hyde Park, O., during 1896–7, following a very limited amount in 1895–6. While it is likely to prove more destructive during certain seasons than during others, downy mildew must be counted, for the present, a probable attendant upon pickle



Map showing known distribution of downy mildew and anthracnose of cucumbers. The Iowa locality for anthracnose is one in greenhouse recorded by Halsted.

growing and treatment be made to prevent it. Not only may Ohio pickle growers expect the downy mildew in 1898, but the probable local appearance of another destructive disease, the anthracnose, as well.

CUCUMBER ANTHRACNOSE.

A brief note upon this trouble was made in Bulletin 73, and its attacks upon cucumbers were predicted, since the same fungus had pre-

viously been found upon beans and watermelons. Like the downy mildew, authracnose is a fungous disease, but differing in that it is caused by the anthracnose fungus *Colletotrichum lagenarium* (Pass.) Hals. This disease appeared the past season upon cucumbers near Cuyahoga Falls, Summit county. The difference in the appearance of leaves attacked by anthracnose and those affected with downy mildew is usually quite clear. Instead of the obscure spotting and general yellowing, as in downy mildew, definite spots are commonly attacked and destroyed; these at once turn brown and die. They are rather large, one-half inch or less across, nearly circular, and soon break up more or less. The anthracnose also attacks the stems of the cucumber, and in this way may cause very rapid destruction of the entire plant. The spots upon the stems are elongated and light brown in color. They are also represented in Plate II. The disease is known upon cucumbers, at the present, in but the one locality, but it may be expected to become in time generally distributed. Its manner of spread is about the same as for the mildew. Growers are warned that the anthracnose will complicate pickle farming by giving two probable fungous diseases instead of one. The anthracnose may prove rather more difficult to prevent by the use of fungicides than appears to the case with downy mildew. Yet spraying is the best remedy that can, at present, be offered. Bordeaux mixture promises to check it very decidedly.

PREVENTION OF DOWNY MILDEW AND ANTHRACNOSE.

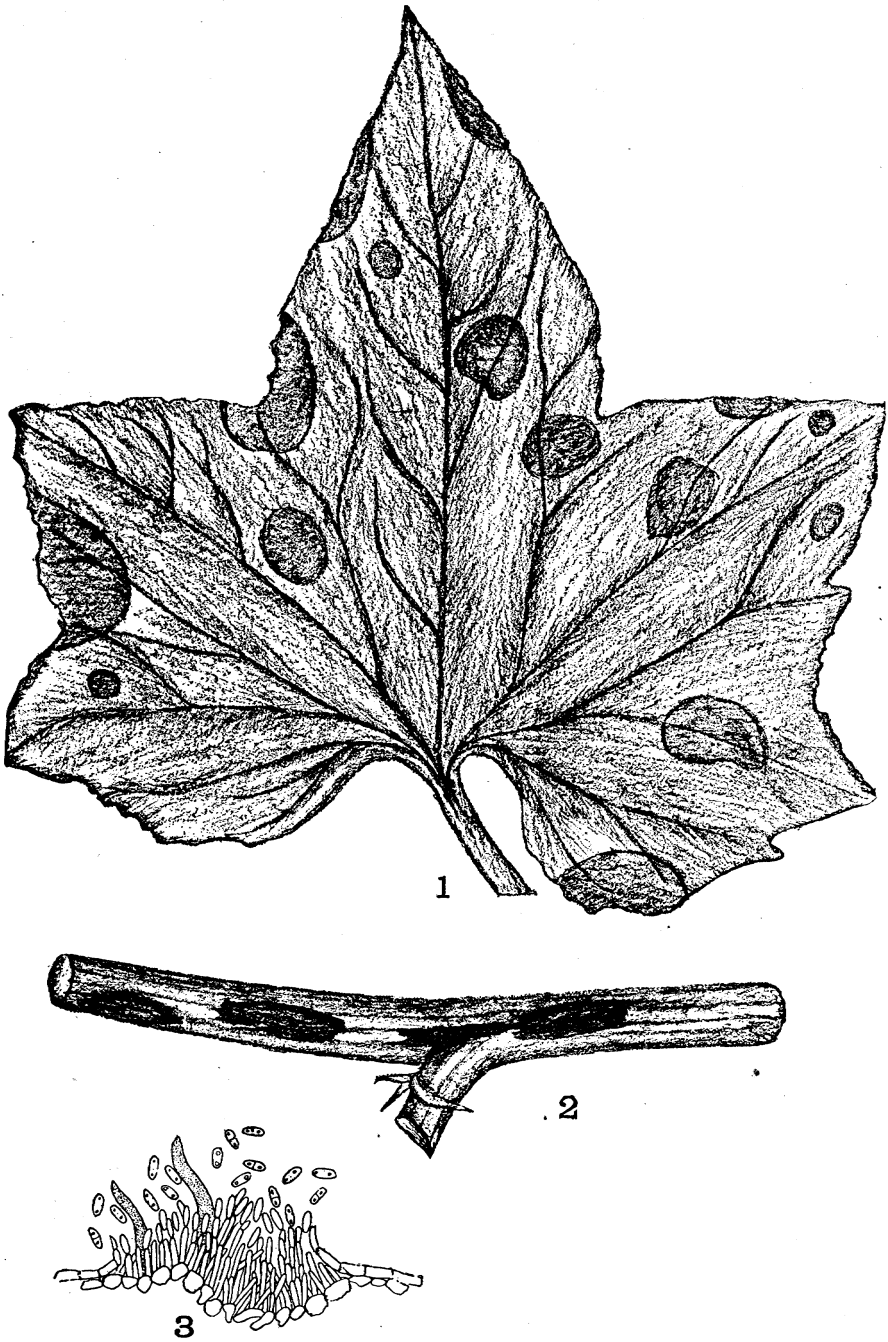
We have seen how the downy mildew is distributed by its spores, and that by keeping the upper surfaces of the leaves continuously covered with the fungicide, the spores will be destroyed or prevented from germination. The best fungicide for this purpose is Bordeaux mixture, of the strength indicated "Bordeaux I," in the spray calendar. It is made [15] by using four pounds of copper sulfate or blue vitriol and four pounds of fresh quicklime to fifty gallons of water. Full directions and cautions will be found in the calendar and do not need to be restated here. This mixture is applied as a fine spray to the leaves and vines; the application being repeated as often as is necessary to keep them well covered with the fungicide. The directions given in the calendar for cucumber anthracnose will apply fairly well to downy mildew likewise. In case of frequent showers and during the month of August the applications will need to be made at shorter intervals than recommended, or about every seven to ten days.

Bulletin 119, of the New York Agricultural Experiment Station,[16] gives the results of a very successful experiment in the use of Bordeaux

[15] Bulletin 79, 97-8 and calendar supplement.

[16] The Downy Mildew of the Cucumber; what it is and how to prevent it March, 1897, by F. C. Stewart.

PLATE II.



Cucumber Anthracnose. Fig. 1, cucumber leaf attacked by anthracnose, three-fourths natural size. Fig. 2, portion of diseased stem, natural size. Fig. 3, section of an acervulus of the anthracnose fungus, *Colletotrictum lagenarium*, showing setæ, spores and spore-bearing branches, magnified about 500 diameters. (From drawing by Mrs. Selby.)

mixture for downy mildew, during 1896. Dr. B. D. Halsted,[17] of the New Jersey Experiment Station, made earlier trials where downy mildew and anthracnose were both present. His results are stated in a former bulletin of this Station.[18] The New York experiment was carried out at Woodbury, Queens Co., (Long Island) upon a pickle field of one and three-fourths acres. Three plots, of ten rows each, were sprayed seven times with varying strengths of Bordeaux mixture; two additional rows were sprayed four times and check plots were left untreated. The sprayings were made July 13, 24, August 3, 12-13, 21-25, September 2-3, and 8-9, using a knapsack sprayer. The mildew attacked the unsprayed plants as early as August 7th, and by the 21st of August they were practically destroyed. "The thirty-two rows of plants which had been sprayed were in perfect health and vigor on August 21st, and *after this date produced two hundred and sixty dollars worth of cucumbers*, which represents approximately the benefit resulting from spraying."[19] By the high price obtained for the pickles—nearly four times the regular contract price for that region—this showing appears very large. The cost of spraying was there computed at $9.50 per acre, the total receipts after August 21st, $173.00 per acre, leaving in this case a net profit of $163.50 per acre. Dividing this return per acre by four, and subtracting cost of spraying, to express the result more nearly in terms of salting house prices in Ohio, it will give $33.75 per acre, net profit. The cost of spraying seven times per acre, $9.50, is about that of well organized field practice and with fewer conveniences the cost need not greatly exceed the amount stated. We must remember, also, that such extremely favorable results cannot be obtained every year.

AN OHIO EXPERIMENT WITH DOWNY MILDEW.

Mr. D. E. McIlvaine, of Creston, acted upon the suggestion to try spraying; on August 26th he applied Bordeaux mixture to the east half of twenty-five rows of his pickle field, plotted in lots of ten, ten and five rows respectively. He readily consented to an arrangement whereby the spraying was continued by the Station. Accordingly the whole of the twenty-five rows was sprayed upon August 30th and 31st and September 3d and 4th, with Bordeaux mixture of the seventy-five gallon formula (1 to 12.) Two hundred gallons of the mixture was used for both applications and thirty-three hours labor was required. It was so late when the spraying was begun that little or no resulting benefit was expected, more especially since it lay quite near badly diseased fields. When the time came for an additional application the leaves were beginning to show the downy mildew and none was made. The results are well stated by Mr. McIlvaine as follows:

---

[17] Report of Botanist N. J. Experiment Station, 1894, p. 347. See also report for 1893.

[18] Bulletin 73, p. 235.

[19] Stewart, loc.-cit. p. 170.

"Now as to the effect, I picked

On September 3, on ten unsprayed rows					5¾	bushels.
"	8,	"	"	"	6	"
"	11,	"	"	"	2	"
"	13,	"	"	"	2	"
Total on ten unsprayed rows after September 3					15¾	"
" Picked September 3, on twenty-five sprayed rows					13	"
"	8,	"	"	"	10½	"
"	11,	"	"	"	10	"
"	13,	"	"	"	11	"
"	17,	"	"	"	5½	"
"	20,	"	"	"	1	"
Total on twenty-five sprayed rows					51	"

"So much in regard to *quantity*. There was a decided improvement in the quality of the cucumbers before any increase in yield was noticeable, and continued to close of season. This I consider a very important result in favor of spraying. You will please pardon me if I suggest that, if an experiment is to be conducted next season in spraying cucumbers, the proportion of marketable and unmarketable cucumbers on the sprayed and unsprayed portions should be ascertained. I believe it would reveal some startling surprises in favor of spraying. In a season like the past the contrast might have been greater than it would in an ordinary season.

The crop this year from three acres was	220 bushels.
The same ground gave last year	725 bushels.
Two and one-half acres of the same ground, gave, in 1895	1,290 bushels."

Returning to Mr. McIlvaine's yields on sprayed and unsprayed rows:

25 sprayed rows gave, after September 3	51 bushels.
10 unsprayed rows gave, for same time	15¾ bushels.
Or, for 25 unsprayed it would be	38.4 bushels.
Difference in favor of treated rows	12.6 bushels.

This reckoned at 37½ cents per bushel gives a return of $4.73. The cost of spraying for the two full applications was:

Labor, 33 hours, at 11½ cents per hour	$3 80
Materials for 200 gallons Bordeaux mixture, at 8 cents per pound for copper sulfate	1 68
Total	$5 48

The increase of product in this case scarcely pays the cost, but at wholesale price of copper sulfate, 5 cents per pound, the difference is less. As before stated any favorable result from spraying begun so late was scarcely to be expected. The area sprayed was 1.02 acres.

Six to eight sprayings will be needed for downy mildew, of which four will be upon full foliage. These four later sprayings will require an average of about 100 gallons per acre for each application; the three earlier, if seven are made in all, about 50 gallons per acre for each application. Three men, with two lines of hose, a horse and cart sprayer,

will apply about one barrel, or 50 gallons, of mixture per hour, or with everything in readiness, 12 barrels per day, of 10 hours. This labor is worth, with horse, about $4.50 per day or 45 cents per hour, or per barrel of mixture applied. The cost of spraying an acre of pickle-vines will therefore be about as follows for seven applications:

Eleven barrels (550 gallons) Bordeaux mixture at 25 cents per barrel (½ cent per gallon)	$2 75
For 11 hours labor, three men and horse, at 45 cents per hour	4 95
Total	$7 70

If eight cents per pound is paid for copper sulfate the cost becomes:

Eleven barrels, (550 gallons) Bordeaux mixture, at 27½ cents per barrel (¾ of a cent per gallon)	$4 12½
Labor as before, 11 hours, at 45 cents	4 95
Total	$9 17½

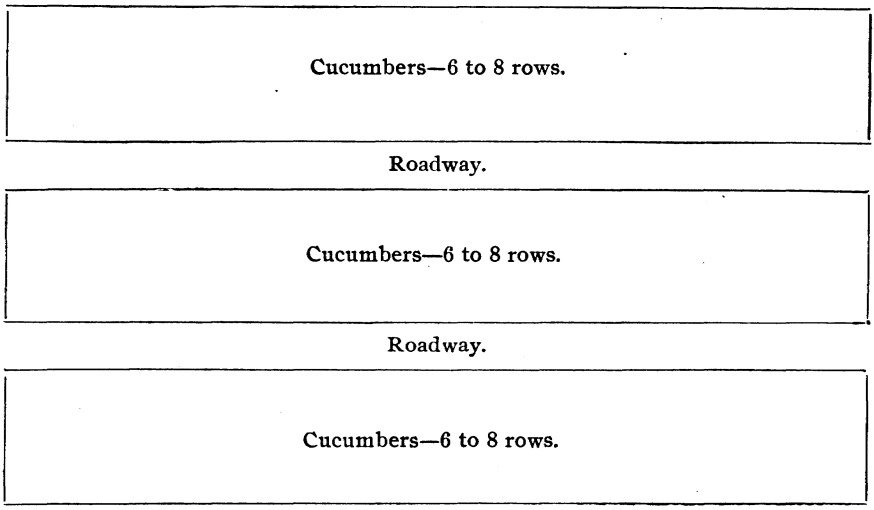
With use of knapsack sprayer the cost of labor will probably be larger, while it may be reduced with a good "crew" and outfit.

SUGGESTIONS AS TO CUCUMBER SPRAYING.

First get the spray calendar and study suggestions as to saving of time in making the spraying mixture. Secure a suitable outfit with the best of nozzles. A nozzle to be of value must make a fine spray. The double Vermorel or double Bordeaux are useful sorts. Spraying is arduous work at best and a good pump is a necessity; Bordeaux mixture soon corrodes the metal and only brass working parts should be used for valve and cylinders. A good pump, also, should have an agitator to keep the mixture stirred. A good sized air chamber is a great advantage. A barrel or tank sprayer, mounted on a cart or wagon, will prove most satisfactory in the end. This outfit should be provided with two lines of hose, each with shut-off cock and double nozzle. For orchard work we find 25 feet of high grade hose, one-half inch bore, with 6-foot rod and shut-off at base, a suitable outfit. For cucumbers an arm support on each side of the cart will prove a convenience in preventing the hose from dragging over the vines. For this work so long a rod will not be needed, but as most growers will also have trees to spray, the extension rod is a good thing to have. Indeed a rod is indispensable to bring the nozzle near the vines without stooping.

Pumps for barrel or tank having attachments for two lines of hose may be bought at from $9.00 or $10.00 upward. The list of manufacturers given (p. 115) will enable prospective purchasers to select what they desire. Good, strong, half-inch hose, a good pressure, and good nozzles, are all essential to get a fine spray. Be ready to do the spraying when it is needed and do not be afraid of a little rain falling afterward.

The question will at once be raised as to how a cart sprayer may be used in the cucumber field when the rows are commonly but 6 feet apart. The writer has suggested that the field be divided into plots of 6 to 8 rows each. Between these rows, if needed, the spaces could be reduced 6 to 10 inches each and between the plots a wider way of 9 or 10 feet be left for the spray cart. Even should wheel pruning of the vines occur later in the season no harm would result. This idea may be expressed in the following diagram:



Stewart has suggested that two rows of late cabbage, cauliflower or other low growing crop may be planted in the roadway, say 3 feet apart. Between these rows the horse may walk, while the wheels run outside of them and between cabbage and cucumbers. In this manner each man sprays three or four rows of cucumbers on each side by a single driving of the cart. The number of rows may be apportioned to their length. A barrel of mixture will cover about one acre, and in this manner extra driving may be avoided. Carrots, parsnips and some other crops suggest themselves for drive-way rows.

MANUFACTURERS OF SPRAY PUMPS AND ACCESSORIES.

The following manufacturers of spraying machinery will be able to supply outfits of various grades and prices:

The Bean Chamberlain Manufacturing Co., Hudson, Mich.
The Deming Co., Salem, Ohio.
Field Force Pump Co., Lockport, N. Y.
The Goulds Manufacturing Co., Seneca Falls, N. Y.
The Humphrey's Manufacturing Co., Mansfield, O.
Morrill & Morley, Benton Harbor, Mich.
F. E. Myers & Bro., Ashland, O.
The Nixon Nozzle and Machine Co., Dayton, O.

Many of the above make knapsack sprayers as well as the barrel pumps for cart or wagon.

THE PICKLE OUTLOOK AND SPRAYING.

With pickle stocks shortened, prices have advanced sharply. Pickles, salt stock, run of vat, $1\frac{1}{2}$ to 4 inches long, are now quoted at 65 to 70 cents per bushel against 50 to 60 cents per bushel a year ago.* The condition of the cucumber pickle market is therefore somewhat in the condition of the wheat market; the supply is short. Manifestly it is but just that the grower should secure his portion of this rise in prices, and he will be careless of his interests if he does not obtain an advance in the price of his pickles. A reasonable advance will surely be granted by the salting houses, since the stock is for a higher market. In this way, by preparations for spraying and careful attention to that work, there is no good reason why reasonable certainty may not again enter into the calculations of the pickle grower. An increased cost of $10.00 per acre from spraying calls for 36 bushels more pickles per acre at 40 cents, or $28\frac{1}{2}$ bushels more at 50 cents per bushel, or $23\frac{3}{4}$ bushels more at 60 cents per bushel for the crop. This, with an allowance of thirty per cent. for picking and marketing. Granted a fair advance in prices it seems that, with an added expense for spraying, the pickle grower may still make the industry fairly remunerative. Without spraying this appears very uncertain by reason of the ravages of the disease.

Sprayed cucumbers may seem objectionable to some by reason of the copper compounds adhering to them, but this amount is so small as to be insignificant. Yet, granting a dangerous amount, it will all be removed by the baths through which the cucumbers pass in their preparation. Very dilute vinegar dissolves the Bordeaux mixture readily.

*Since writing the above I have been informed that 25000 bushels of such stock recently sold in Chicago at about $1.00 per bushel.

NOTES ON MELON LEAF BLIGHTS.

The new leaf blight of muskmelons *Alternaria sp*, described and figured in Bulletin 73, reappeared during the season of 1897, with increased virulence. During this season its attacks were extended to watermelon leaves. It was usual, when finding both muskmelons and watermelons growing together, to discover that both were diseased. The muskmelon leaves commonly showed the earliest symptoms, dying off rapidly with the characteristic dead spotting. The watermelon leaves were soon attacked; the fungus produces in them circular, dark brown spots. The appearance of this fungus upon the watermelon plants has not been previously noted, so far as I am aware. Together with the anthracnose, the *Alternaria* was earliest noted upon muskmelons at Marietta, August 3d. At that date but a few leaves were attacked. It made its appearance near Wooster about August 15th. The universal complaint of inferior quality of muskmelons appeared to be well founded. Most of the melons were of poor quality because coming from diseased vines. The losses were very considerable in all muskmelon districts of the State, so far as heard from. Mr. Shirer places the loss near Dayton at fifty per cent. of the crop, and Mr. Rose lost more than half his crop at Trinway, Muskingum county. These are probably to be attributed to the leaf blight. The same state of things was reported in Summit county, but the losses there resulted from downy mildew where examined. In all cases but a few of the early melons ripened naturally or properly. In nearly every instance the watermelon leaves were also spotted. Mr. Rose reports that his watermelons became spotted over the surface of the fruit and were bitter when so affected. This is due to the melon anthracnose, *Colletotrichum lagenarium* (Pass.) Hals., the same fungus that attacks cucumbers. The conditions under which these diseases spread are similar to those described for downy mildew of the cucumbers; hot weather with heavy dews or repeated showers are most favorable.

We are not able to report wholly successful nor wholly unsuccessful results from spraying during the past season for leaf blight; while some spraying was done and with apparent success, the benefits do not admit of computation. The use of Bordeaux mixture is still recommended for the melon leaf blight, downy mildew and anthracnose. Five to seven applications as per the calendar are thought to promise good return. In this as in the cucumber spraying the method of planting will need to be such as to admit of use of cart sprayer, unless indeed the grower desires the more expensive treatment with the knapsack sprayer.

TOMATO LEAF BLIGHT.

This new disease of garden tomatoes, described and illustrated in the same bulletin as the preceding trouble, has spread over remote parts of the State. It is a fungous disease, caused by the leaf blight-fungus, *Septoria Lycopersici* Speg. It produces very small dead spots in the leaves and upon the stems; these are first noticeable in the end of the tip leaflets of the older leaves. After many of the leaves are destroyed the fungus extends its ravages to the stems, when the crop is much shortened, and few fruits are formed.

The leaf blight reappeared at Marietta very early in the season: August 4th the fields showed dead leaves below to a height of about three feet, and perhaps two feet of branches with green leaves above on the staked tomato rows. It did not reduce the early market supply so seriously as the later crop. The same trouble was seen at Wooster August 7th, and spraying was then begun. The leaf blight appeared about Mt. Carmel, Clermont county, August 10th to 15th. Upon the latter date half the leaves of some plants were reported dead. The same disease was prevalent about Creston, Wayne county, about Columbus, Franklin county, and was observed at Ashtabula, Ashtabula county. Judging by what has already happened, this fungous disease will, in time, involve all the tomato growing districts of the State.

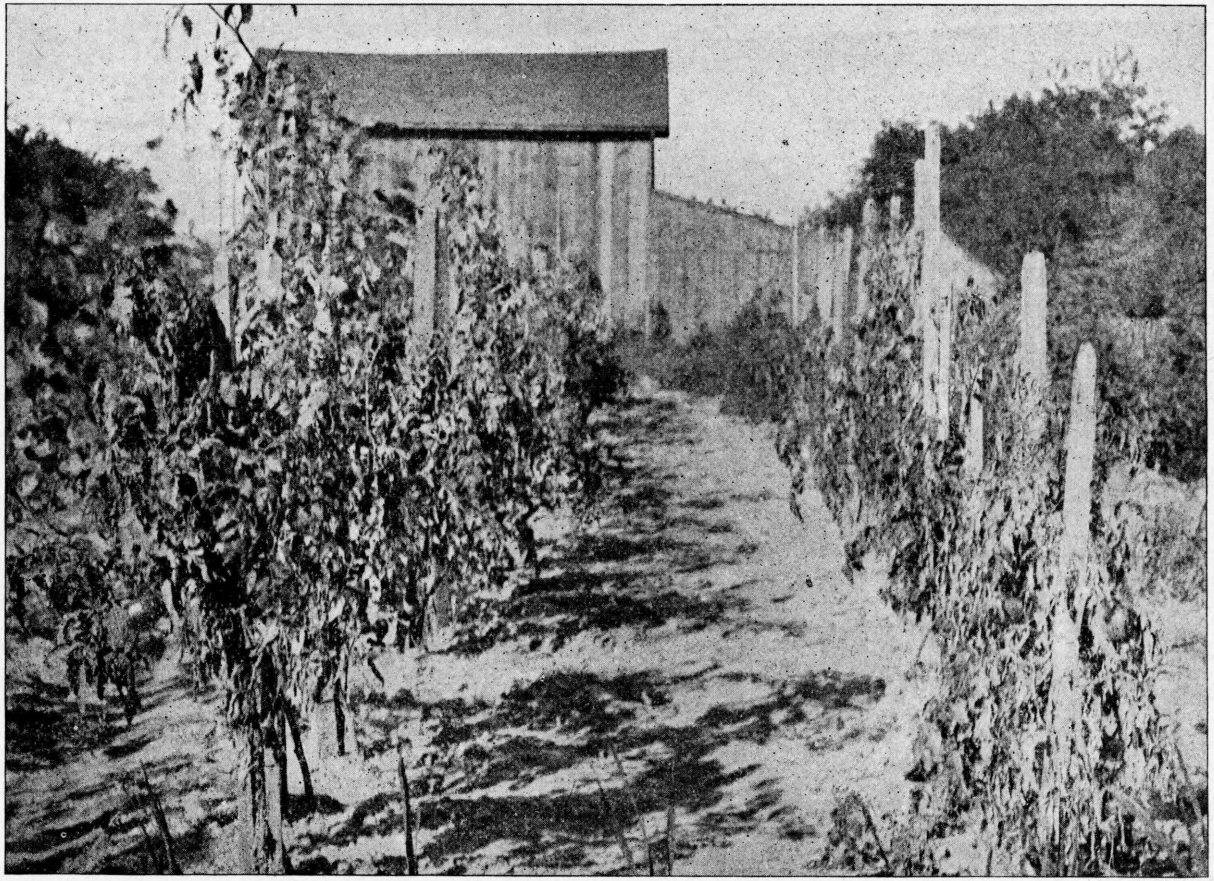
LOSSES CAUSED BY THE TOMATO LEAF BLIGHT.

The injuries from this trouble are not so marked as in the case of downy mildew of cucumbers. They are manifest only in a reduced yield. Mr. G. R. Johnson, of Mt. Carmel, who grows tomatoes for a canning factory, places his loss from leaf blight at 12 to 15 per cent. of the crop; that is, 25 to 30 bushels per acre loss. The tomato crop was light where only the season's conditions were to contend with. Perhaps in some instances the presence of the blight was overlooked for that reason.

PREVENTION OF TOMATO LEAF BLIGHT.

As a matter of record it will be well to state here, that of two plots of tomatoes, only four or five rods apart, in the disease garden of the Station, only that plot planted where diseased plants grew a year ago was attacked by the blight; the other was entirely free from it. The old patch may prove a source of infection. It is possible that the disease may be transmitted by the seed, although much less liable to be so scattered than the anthracnose which attacks the fruit. To discover what treatment might be given the seeds of tomato without injury, some experiments in seed treatment were carried out by Mr. B. H. Thorne, under the writer's direction. Copper sulfate solution, 10 per cent. strength, with 1 and 2 hours immersion of the seeds, did not injure their germination. Hot water, 133° F., five minutes immersed, did no injury, while ten minutes immersion impaired the vitality of the seeds to some extent.

PLATE III.



Tomato Leaf Blight. At the left is shown the row sprayed three times with Bordeaux mixture; at the right the unsprayed row. From photograph taken September 23rd, 1897.

The treatments indicated should be sufficient to destroy adhering spores. It is plain that our reliance for leaf blight must be upon fungicides and spraying.

Two rows of tomatoes were planted for this experiment; each contained at the outset 27 plants, with but one missing in each row. The south row was sprayed with Bordeaux mixture, 75 gallon formula, upon August 11th and 20th, and September 2d. The result was very striking. The cut shows these two rows, looking from the east. The one upon the left received the three sprayings as stated, while the other received no fungicide upon the leaves. September 17th it was noted that the untreated plants had but few green leaves and that the stems were diseased, while in the treated row the plants had four or five times as much foliage and no affected stems. A few of the older leaves on this row died from the disease. Doubtless this would not have occurred had the spraying been begun two or three weeks earlier. No account was made of the fruit, which was of larger quantity upon the treated plants. From this experiment it seems that three or four sprayings with Bordeaux mixture, begun after the first blossoms, as per calendar, will successfully check the leaf blight. It will be more difficult to treat unstaked vines than where the plants are tied up, but there seems no good reason to think the treatment will be less effective.

SUMMARY.

1. The industry of cucumber pickle growing, a new and increasing one for Ohio, has met a serious difficulty in the rapid decrease of yield. The yield for 1897 is but about 33 per cent. of a fair average return.

2. The chief cause of diminishing pickle yields is found in the work of the downy mildew fungus, *Plasmopara Cubensis*, which attacks the cucumber plant in both fields and forcing houses. Its ravages have been noted in several states.

3. For Wayne county, Ohio, this fungous disease has caused in 1897 a loss of about 66⅔ per cent. of the crop. Computed at an average of 210 bushels per acre and one-third large pickles, this loss at factory prices reaches almost $45,000 for the single season in Wayne county.

4. The fungus of downy mildew is spread by spores, that, alighting upon the upper leaf surface, germinate there and grow into the leaf through the pores or stomates, developing within the leaf a larger fungous growth and robbing the cucumber plant. The fungus may also attack melons, pumpkins and squashes.

5. First appearing in the United States in 1889, in New Jersey, this fungus has spread to New York, Ohio and Illinois, also to Florida and Texas. It may be expected to extend its ravages into new districts.

6. Cucumber anthracnose, a fungous disease affecting leaves, fruits and stems, has appeared in Ohio. Its extension may likewise be expected.

7. These two diseases may be very largely if not entirely suppressed by spraying about seven times with Bordeaux mixture, making the first application as the plants begin to vine, and keeping the leaves covered with the fungicide thereafter, until about September 10. The cost for these sprayings need not exceed $10.00 per acre, and may be reduced to $7.50.

8. The use of the fungicide makes it feasible to contemplate further pickle farming, while little encouragement can be offered without the use of the spraying mixtures.

9. Melon leaf blight, *Alternaria sp.*, whose occurrence has been previously noted, is reported during 1897 to have reduced the muskmelon crop by nearly 50 per cent. in Ohio. The same fungus has this season attacked watermelon leaves. The same remedy is recommended as for cucumber diseases.

10. Tomato leaf blight fungus, *Septoria Lycopersici* has become disseminated throughout most of Ohio. The successful prevention of this disease may be attained through the use of Bordeaux mixture and with about half the number of applications required for the cucumber and the melon troubles.

11. The possibility of treatment of tomato seeds with certain fungicides, without injury to seeds has been demonstrated so far as may be done in a single series of trials. In the absence of anthracnose these trials were without positive result in the prevention of disease.